

Cambridge University Press

978-1-107-40985-9 - Materials Research Society Symposium Proceedings: Volume 227:

Materials Science of High Temperature Polymers for Microelectronics

Editors: D. T. Grubb, Itaru Mita and D. Y. Yoon

Frontmatter

[More information](#)

Materials Science of High Temperature Polymers for Microelectronics

Cambridge University Press

978-1-107-40985-9 - Materials Research Society Symposium Proceedings: Volume 227:
Materials Science of High Temperature Polymers for Microelectronics

Editors: D. T. Grubb, Itaru Mita and D. Y. Yoon

Frontmatter

[More information](#)

Cambridge University Press

978-1-107-40985-9 - Materials Research Society Symposium Proceedings: Volume 227:

Materials Science of High Temperature Polymers for Microelectronics

Editors: D. T. Grubb, Itaru Mita and D. Y. Yoon

Frontmatter

[More information](#)

MATERIALS RESEARCH SOCIETY SYMPOSIUM PROCEEDINGS VOLUME 227

Materials Science of High Temperature Polymers for Microelectronics

Symposium held April 29-May 2, 1991, Anaheim, California, U.S.A.

EDITORS:

D.T. Grubb

Cornell University, Ithaca, New York, U.S.A.

Itaru Mita

Dow Corning Japan Ltd., Kanagawa, Japan

D.Y. Yoon

IBM Almaden Research Center, San Jose, California, U.S.A.



MATERIALS RESEARCH SOCIETY

Pittsburgh, Pennsylvania

Cambridge University Press

978-1-107-40985-9 - Materials Research Society Symposium Proceedings: Volume 227:

Materials Science of High Temperature Polymers for Microelectronics

Editors: D. T. Grubb, Itaru Mita and D. Y. Yoon

Frontmatter

[More information](#)

CAMBRIDGE UNIVERSITY PRESS

Cambridge, New York, Melbourne, Madrid, Cape Town,
Singapore, São Paulo, Delhi, Mexico City

Cambridge University Press

32 Avenue of the Americas, New York NY 10013-2473, USA

Published in the United States of America by Cambridge University Press, New York

www.cambridge.org

Information on this title: www.cambridge.org/9781107409859

Materials Research Society

506 Keystone Drive, Warrendale, PA 15086

<http://www.mrs.org>

© Materials Research Society 1991

This publication is in copyright. Subject to statutory exception
and to the provisions of relevant collective licensing agreements,
no reproduction of any part may take place without the written
permission of Cambridge University Press.

This publication has been registered with Copyright Clearance Center, Inc.
For further information please contact the Copyright Clearance Center,
Salem, Massachusetts.

First published 1991

First paperback edition 2012

Single article reprints from this publication are available through
University Microfilms Inc., 300 North Zeeb Road, Ann Arbor, MI 48106

CODEN: MRSPDH

ISBN 978-1-107-40985-9 Paperback

Cambridge University Press has no responsibility for the persistence or
accuracy of URLs for external or third-party internet websites referred to in
this publication, and does not guarantee that any content on such websites is,
or will remain, accurate or appropriate.

Contents

PREFACE	ix
MATERIALS RESEARCH SOCIETY SYMPOSIUM PROCEEDINGS	x
PART I: SYNTHESIS AND NEW MATERIALS FOR THIN FILMS	
ORGANO-SOLUBLE, SEGMENTED RIGID-ROD POLYIMIDES: SYNTHESIS AND PROPERTIES	3
F.W. Harris, H.L.C. Hsu, C.J. Lee, B.S. Lee, F. Arnold, and S.Z.D. Cheng	
A STUDY OF POLYAMIC-ACID INTERCHANGE REACTIONS	11
J.A. Kreuz and D.L. Goff	
CHEMISTRY AND CHARACTERIZATION OF POLYIMIDES DERIVED FROM POLY(AMIC ALKYL ESTERS)	23
W. Volksen, D.Y. Yoon, J.L. Hedrick, and D. Hofer	
POLYIMIDE COPOLYMERS CONTAINING VARIOUS LEVELS OF THE 6F MOIETY FOR HIGH TEMPERATURE AND MICROELECTRONIC APPLICATIONS	35
M. Haider, E. Chenevey, R.H. Vora, W. Cooper, M. Glick, and M. Jaffe	
FLUORINATED POLYIMIDE BLOCK COPOLYMERS	43
J.W. Labadie, M.L. Sanchez, Y.Y. Cheng, and J.L. Hedrick	
PROPERTY CONTROL OF NEW FLUORINATED COPOLYIMIDES AND THEIR APPLICATIONS	49
S. Sasaki, T. Matsuura, S. Nishi, and S. Ando	
GROWTH OF POLYIMIDE FILMS BY CHEMICAL VAPOR DEPOSITION AND THEIR CHARACTERIZATION	55
S.P. Kowalczyk, C.D. Dimitrakopoulos, and S.E. Molis	
POLY(ENAMINONITRILES): NOVEL MATERIALS FOR USE IN MICROELECTRONICS	61
J.A. Moore and J-H. Kim	
PREPARATION OF POLYIMIDE-SILICA HYBRID FILMS	69
M.-A. Kakimoto, A. Morikawa, Y. Iyoku, and Y. Imai	
IMIDE-ARYL ETHER KETONE BLOCK COPOLYMERS	81
J.L. Hedrick, W. Volksen, and D.K. Mohanty	
PREPARATION AND CHARACTERIZATION OF THERMOPLASTIC/ THERMOSETTING POLYIMIDE BLENDS	89
Y. Yamamoto, T. Toyoshima, and S. Etoh	

Cambridge University Press

978-1-107-40985-9 - Materials Research Society Symposium Proceedings: Volume 227:

Materials Science of High Temperature Polymers for Microelectronics

Editors: D. T. Grubb, Itaru Mita and D. Y. Yoon

Frontmatter

[More information](#)

HIGHLY TEMPERATURE RESISTANT SILICONE LADDER POLYMERS H. Adachi, E. Adachi, S. Yamamoto, and H. Kanegae	95
REAL-TIME FT-IR STUDIES OF THE REACTION KINETICS FOR THE POLYMERIZATION OF DIVINYLSILOXANE BIS-BENZOCYCLOBUTENE MONOMERS T.M. Stokich, Jr., W.M. Lee, and R.A. Peters	103
PART II: CHARACTERIZATION, STRUCTURE AND PROPERTIES	
INTRAMOLECULAR CHARGE TRANSFER IN AROMATIC POLYIMIDES J.M. Salley, T. Miwa, and C.W. Frank	117
CT FLUORESCENCE AND MOLECULAR AGGREGATION OF A POLYIMIDE AS A FUNCTION OF IMIDIZATION CONDITION M. Hasegawa, H. Arai, K. Horie, R. Yokota, and I. Mita	125
A FLUORESCENCE STUDY OF POLYIMIDE CURE KINETICS D.A. Hoffmann, H. Ansari, and C.W. Frank	131
RIGID-ROD AND SEGMENTED RIGID-ROD POLYIMIDES: GEL/SOL AND LIQUID CRYSTALLINE TRANSITIONS, FIBERS AND FILMS S.Z.D. Cheng, F.E. Arnold, Jr., M. Eashoo, S-K. Lee, S.L.C. Hsu, C-J. Lee, and F.W. Harris	137
EFFECT OF MOISTURE ON THE PHYSICAL PROPERTIES OF POLYIMIDE FILMS R. Subramanian, M.T. Pottiger, J.H. Morris, and J.P. Curilla	147
BISMALEIMIDE/ALLYLNADIC-IMIDE BLENDS YIELD LOW DIELECTRIC CONSTANT AND LOW WATER UPTAKE J-Ph. Ansermet and A. Kramer	155
CHARACTERIZATION OF THE BINDING OF INORGANIC POLYMERS TO OXIDE SURFACES BY NMR AND NMR/MAS SPECTROSCOPY S.D. Burton, W.D. Samuels, G.J. Exarhos, and J.C. Linehan	161
PHYSICAL CHARACTERIZATION OF MICROELECTRONIC POLYMERIC THIN FILMS S.D. Senturia, S.C. Noe, and J.Y. Pan	167
THE DETERMINATION OF THE RESIDUAL STRESS STATE AND ITS EFFECT ON PEEL TESTS IN POLYIMIDE COATINGS R.J. Farris, M.A. Maden, J. Goldfarb, and K. Tong	177
INTERNAL STRESS DEVELOPMENT IN SPIN COATED POLYIMIDE FILMS M.T. Pottiger and J. Coburn	187
STRESS MEASUREMENT OF BPDA/PDA POLYIMIDES FROM POLY(AMIC ACID) AND PHOTSENSITIVE POLYIMIDE PRECURSORS ON SILICON H. Nomura, M. Eguchi, K. Niwa, and M. Asano	195
PROPERTIES OF A PHOTOIMAGEABLE THIN POLYIMIDE FILM II T. Maw and R.E. Hopla	205

Cambridge University Press

978-1-107-40985-9 - Materials Research Society Symposium Proceedings: Volume 227:

Materials Science of High Temperature Polymers for Microelectronics

Editors: D. T. Grubb, Itaru Mita and D. Y. Yoon

Frontmatter

[More information](#)

STRUCTURE AND PROPERTIES OF BPDA-PDA POLYIMIDE FILM FROM ITS POLY(AMIC ACID) PRECURSOR COMPLEXED WITH AN AMINOALKYL METHACRYLATE	211
M. Ree, T.L. Nunes, K-J.R. Chen, and G. Czornyj	
THERMAL EXPANSION AND VISCOELASTIC PROPERTIES OF A SEMI-RIGID POLYIMIDE	219
T.L. Smith and C.S. Kim	
ELECTRICAL PROPERTIES OF THIN POLYIMIDE FILMS PREPARED BY IONIZED CLUSTER BEAM DEPOSITION	225
H-J. Jung, D-H. Lee, J-K. Lee, and C-N. Whang	
CHANGES IN THE CHARACTERISTICS OF THE FREE VOLUME OF GLASSY POLYMERS DURING DEFORMATION AND RELAXATION	231
M.I. Tsapovestsky, V.K. Lavrentiev, and S.A. Tishin	
DIELECTRIC RELAXATION OF SEMI-CRYSTALLINE POLYIMIDES	239
P. Huo, J. Friler, and P. Cebe	
PART III: APPLICATIONS AND PROCESSING	
POLYIMIDE CONSIDERATIONS IN THIN-FILM ELECTRONIC PACKAGING	247
W.P. Pawlowski	
UV-LASER PHOTOABLATION OF THERMOSTABLE POLYMERS: POLYIMIDES, POLYPHENYLQUINOXALINE AND TEFLON AF	253
S. Lazare, H. Hiraoka, A. Cros, and R. Gustiniani	
SPIN COATING PLANARIZATION OF INTEGRATED CIRCUIT TOPOGRAPHY ON A ROTATING DISK	259
R.K. Yonkoski and D.S. Soane	
POLYIMIDE PLANARIZATION WITH POLYSTYRENE BY RIE ETCH-BACK	265
H.Y. Ng, T. Lii, and M. Jaso	
PROTONATION EFFECTS ON PPQ POLYMER DURING HF LIFT-OFF PROCESS USED IN MULTICHIP MODULE FABRICATION	273
F. Templier, J. Torres, C. Clarisse, and J. Palleau	
PART IV: THERMOTROPIC LIQUID CRYSTALLINE POLYMERS	
LIQUID CRYSTALLINE THERMOSETS AS MATERIALS FOR MICROELECTRONICS	281
C.K. Ober and G.G. Barclay	
THERMOTROPIC POLYESTERS CONTAINING CARBONYL OR ETHER LINKAGES	293
R.S. Irwin	
UNSYMMETRICAL SPACERS: A NEW CONCEPT FOR SYNTHESIS OF MAIN-CHAIN LIQUID CRYSTALLINE POLYMERS	307
R. Kosfeld, G. Poersch, and M. Hess	
PHASE TRANSITIONS IN BLENDS OF LIQUID CRYSTALLINE POLYMER/POLYETHER IMIDE	313
J. Nam, T. Fukai, and T. Kyu	

Cambridge University Press

978-1-107-40985-9 - Materials Research Society Symposium Proceedings: Volume 227:

Materials Science of High Temperature Polymers for Microelectronics

Editors: D. T. Grubb, Itaru Mita and D. Y. Yoon

Frontmatter

[More information](#)

PART V: SURFACES, INTERFACES AND ADHESION

PREPARATION OF MOISTURE RESISTANT POLYIMIDE FILMS BY PLASMA TREATMENT M.A. Petrich and H.Y. Lu	323
SURFACE PROPERTIES OF PHOTOABLATED THERMOSTABLE POLYMERS H. Hiraoka, S. Lazare, A. Cros, and R. Gustiniani	329
A CALORIMETRIC EVALUATION OF THE PEEL ADHESION TEST J.L. Goldfarb, R.J. Farris, Z. Chai, and F.E. Karasz	335
A NOVEL PHOTOCHEMICAL ROUTE FOR MODIFYING SURFACES: PROSPECTS AND APPLICATIONS M.A. Harmer	341
CONTROL OF POLYIMIDE SURFACE PROPERTY BY CHANGING THE SURFACE MORPHOLOGY K-W. Lee	347
THE ROLE OF SURFACE MODIFICATION ON ADHESION AT THE METAL/POLYMER INTERFACE M.J. Berry, I. Turlik, P.L. Smith, and G.M. Adema	351
A STUDY OF THE INTERFACE BETWEEN POLYIMIDE AND PLATED COPPER Y. Morihiro, K. Miyake, M. Mori, H. Kurokawa, M. Kohara, and M. Nunoshita	357
ADHESION OF COPPER TO POLYTETRAFLUOROETHYLENE POLYMER FILM WITH ADHESIVE LAYERS C-J. Chan, C-A. Chang, and C.E. Farrel	363
VI. LATE PAPERS ACCEPTED	
STRUCTURE AND PROPERTIES OF BINARY RODLIKE/FLEXIBLE POLYIMIDE MIXTURES S. Rojstaczer, M. Ree, D.Y. Yoon, and W. Volksen	371
STIFF POLYIMIDES: CHAIN ORIENTATION AND ANISOTROPY OF THE OPTICAL AND DIELECTRIC PROPERTIES OF THIN FILMS D. Boese, S. Herminghaus, D.Y. Yoon, J.D. Swalen, and J.F. Rabolt	379
CHAIN CONFORMATIONS OF AROMATIC POLYIMIDES AND THEIR ORDERING IN THIN FILMS D.Y. Yoon, W. Parrish, L.E. Depero, and M. Ree	387
AUTHOR INDEX	395
SUBJECT INDEX	397

Cambridge University Press

978-1-107-40985-9 - Materials Research Society Symposium Proceedings: Volume 227:

Materials Science of High Temperature Polymers for Microelectronics

Editors: D. T. Grubb, Itaru Mita and D. Y. Yoon

Frontmatter

[More information](#)

Preface

A Symposium on Materials Science of High Temperature Polymers for Microelectronics was held from April 29th to May 2nd 1991 in Anaheim, California, as Symposium J of the 1991 MRS Spring Meeting. Previous meetings concentrating on high temperature polymers have primarily considered their use as structural materials. High temperature polymers are finding use in aerospace as matrix and fibers for composites. They are also finding use in microelectronics, as thin films, where the problems are somewhat different. There has also been a tendency to focus more on the engineering or end-use application of these novel materials.

In this symposium, the intention was to have a balance between the end-use materials engineering and a more scientific and general approach. This shows itself in the balance between industrial and academic authors of the papers given. Although the topic of the symposium is very closely focused, it is one of great current interest. Sixty-four papers were presented at the meeting, to an audience sufficient to make the organizers consider moving to a larger room. Of these papers, 50 are included in these proceedings.

The organization of this volume follows that of the meeting. The first two sections are on synthesis and new materials and characterization of structure and properties. They are the largest sections, and there is considerable overlap; most synthetic papers measure some properties; many characterization papers are looking at very new materials. Sections on specific applications and on thermotropic liquid crystalline polymers follow, and finally a more distinct section on surface properties, surface modification and adhesion.

The corporate support of this symposium by IBM Corporation, Hoescht Celanese Corporation, and E.I. duPont de Nemours & Co. enabled us to invite a number of speakers from a wide range of locations. This made the symposium the success that it was, and we are grateful for their support. Many of these invited papers are included in this volume.

D.T. Grubb
I. Mita
D.Y. Yoon

August 1991

Cambridge University Press

978-1-107-40985-9 - Materials Research Society Symposium Proceedings: Volume 227:

Materials Science of High Temperature Polymers for Microelectronics

Editors: D. T. Grubb, Itaru Mita and D. Y. Yoon

Frontmatter

[More information](#)

MATERIALS RESEARCH SOCIETY SYMPOSIUM PROCEEDINGS

- Volume 201—Surface Chemistry and Beam-Solid Interactions, H. Atwater, F.A. Houle, D. Lowndes, 1991, ISBN: 1-55899-093-3
- Volume 202—Evolution of Thin Film and Surface Microstructure, C.V. Thompson, J.Y. Tsao, D.J. Srolovitz, 1991, ISBN: 1-55899-094-1
- Volume 203—Electronic Packaging Materials Science V, E.D. Lillie, P. Ho, R.J. Jaccodine, K. Jackson, 1991, ISBN: 1-55899-095-X
- Volume 204—Chemical Perspectives of Microelectronic Materials II, L.V. Interrante, K.F. Jensen, L.H. Dubois, M.E. Gross, 1991, ISBN: 1-55899-096-8
- Volume 205—Kinetics of Phase Transformations, M.O. Thompson, M. Aziz, G.B. Stephenson, D. Cherns, 1991, ISBN: 1-55899-097-6
- Volume 206—Clusters and Cluster-Assembled Materials, R.S. Averback, J. Bernholc, D.L. Nelson, 1991, ISBN: 1-55899-098-4
- Volume 207—Mechanical Properties of Porous and Cellular Materials, K. Sieradzki, D. Green, L.J. Gibson, 1991, ISBN: 1-55899-099-2
- Volume 208—Advances in Surface and Thin Film Diffraction, T.C. Huang, P.I. Cohen, D.J. Eaglesham, 1991, ISBN: 1-55899-100-X
- Volume 209—Defects in Materials, P.D. Bristowe, J.E. Epperson, J.E. Griffith, Z. Liliental-Weber, 1991, ISBN: 1-55899-101-8
- Volume 210—Solid State Ionics II, G.-A. Nazri, D.F. Shriver, R.A. Huggins, M. Balkanski, 1991, ISBN: 1-55899-102-6
- Volume 211—Fiber-Reinforced Cementitious Materials, S. Mindess, J.P. Skalny, 1991, ISBN: 1-55899-103-4
- Volume 212—Scientific Basis for Nuclear Waste Management XIV, T. Abrajano, Jr., L.H. Johnson, 1991, ISBN: 1-55899-104-2
- Volume 213—High-Temperature Ordered Intermetallic Alloys IV, L.A. Johnson, D.P. Pope, J.O. Stiegler, 1991, ISBN: 1-55899-105-0
- Volume 214—Optical and Electrical Properties of Polymers, J.A. Emerson, J.M. Torkelson, 1991, ISBN: 1-55899-106-9
- Volume 215—Structure, Relaxation and Physical Aging of Glassy Polymers, R.J. Roe, J.M. O'Reilly, J. Torkelson, 1991, ISBN: 1-55899-107-7
- Volume 216—Long-Wavelength Semiconductor Devices, Materials and Processes, A. Katz, R.M. Biefeld, R.L. Gunshor, R.J. Malik, 1991, ISBN: 1-55899-108-5
- Volume 217—Advanced Tomographic Imaging Methods for the Analysis of Materials, J.L. Ackerman, W.A. Ellingson, 1991, ISBN: 1-55899-109-3
- Volume 218—Materials Synthesis Based on Biological Processes, M. Alper, P.D. Calvert, R. Frankel, P.C. Rieke, D.A. Tirrell, 1991, ISBN: 1-55899-110-7

Cambridge University Press

978-1-107-40985-9 - Materials Research Society Symposium Proceedings: Volume 227:

Materials Science of High Temperature Polymers for Microelectronics

Editors: D. T. Grubb, Itaru Mita and D. Y. Yoon

Frontmatter

[More information](#)

MATERIALS RESEARCH SOCIETY SYMPOSIUM PROCEEDINGS

- Volume 219—Amorphous Silicon Technology—1991, A. Madan, Y. Hamakawa, M. Thompson, P.C. Taylor, P.G. LeComber, 1991, ISBN: 1-55899-113-1
- Volume 220—Silicon Molecular Beam Epitaxy, 1991, J.C. Bean, E.H.C. Parker, S. Iyer, Y. Shiraki, E. Kasper, K. Wang, 1991, ISBN: 1-55899-114-X
- Volume 221—Heteroepitaxy of Dissimilar Materials, R.F.C. Farrow, J.P. Harbison, P.S. Peercy, A. Zangwill, 1991, ISBN: 1-55899-115-8
- Volume 222—Atomic Layer Growth and Processing, Y. Aoyagi, P.D. Dapkus, T.F. Kuech, 1991, ISBN: 1-55899-116-6
- Volume 223—Low Energy Ion Beam and Plasma Modification of Materials, J.M.E. Harper, K. Miyake, J.R. McNeil, S.M. Gorbalkin, 1991, ISBN: 1-55899-117-4
- Volume 224—Rapid Thermal and Integrated Processing, M.L. Green, J.C. Gelpey, J. Wortman, R. Singh, 1991, ISBN: 1-55899-118-2
- Volume 225—Materials Reliability Issues in Microelectronics, J.R. Lloyd, P.S. Ho, C.T. Sah, F. Yost, 1991, ISBN: 1-55899-119-0
- Volume 226—Mechanical Behavior of Materials and Structures in Microelectronics, E. Suhir, R.C. Cammarata, D.D.L. Chung, 1991, ISBN: 1-55899-120-4
- Volume 227—High Temperature Polymers for Microelectronics, D.Y. Yoon, D.T. Grubb, I. Mita, 1991, ISBN: 1-55899-121-2
- Volume 228—Materials for Optical Information Processing, C. Warde, J. Stamatoff, W. Wang, 1991, ISBN: 1-55899-122-0
- Volume 229—Structure/Property Relationships for Metal/Metal Interfaces, A.D. Romig, D.E. Fowler, P.D. Bristowe, 1991, ISBN: 1-55899-123-9
- Volume 230—Phase Transformation Kinetics in Thin Films, M. Chen, M. Thompson, R. Schwarz, M. Libera, 1991, ISBN: 1-55899-124-7
- Volume 231—Magnetic Thin Films, Multilayers and Surfaces, H. Hopster, S.S.P. Parkin, G. Prinz, J.-P. Renard, T. Shinjo, W. Zinn, 1991, ISBN: 1-55899-125-5
- Volume 232—Magnetic Materials: Microstructure and Properties, T. Suzuki, Y. Sugita, B.M. Clemens, D.E. Laughlin, K. Ouchi, 1991, ISBN: 1-55899-126-3
- Volume 233—Synthesis/Characterization and Novel Applications of Molecular Sieve Materials, R.L. Bedard, T. Bein, M.E. Davis, J. Garces, V.A. Maroni, G.D. Stucky, 1991, ISBN: 1-55899-127-1
- Volume 234—Modern Perspectives on Thermoelectrics and Related Materials, D.D. Allred, G. Slack, C. Vining, 1991, ISBN: 1-55899-128-X

*Prior Materials Research Society Symposium Proceedings
available by contacting Materials Research Society.*